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Rover Sequencing and Visualization Program (RSVP) for the Mars Exploration Rover Program (MER)

A presentation to the 2002 JPL IT Seminar

Brian Cooper

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Presentation Agenda

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- What is the Rover Sequencing and Visualization Program (RSVP)?
- RSVP Heritage
- Driving Requirements
- RSVP Capabilities and Functional Flow
- How RSVP Fits Into the MER Ground Data System
- Design Philosophy, Assumptions and Constraints
- Program Set Architecture
- Analysis: Tradoffs and Decisions
- Rover Sequence Editor (RoSE)
- Visualization Tools (HyperDrive)

Acknowlegements

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- **RSVP development team**
  - ***Brian Cooper: Cognizant Engineer***
  - ***Frank Hartman: SW Engineer***
  - ***Scott Maxell: SW Engineer***
  - ***John Wright: SW Engineer***
  - ***Jeng Yen: SW Engineer***
  - ***Carlos Balacuit: SW Engineer (former team member)***

What is the Rover Sequencing and Visualization Program (RSVP)?

- RSVP is the key tool used in the MER Ground data system (GDS) for:
  - Interactive visualization of the Martian environment via images, terrain and rover models.
  - Transformation of activity level inputs from the science team and mission planners into command sequences.
  - Generation of all command sequence files to be sent to the rover.

- RSVP is designed to be a user friendly, high performance tool used in many elements of the operations uplink process for MER.
- RSVP provides an interface to the over 800 complex rover commands and allows the ops team to develop command sequences that are validated and provide a maximum science return
- RSVP utilizes state of the art real time computer graphics techniques to provide a virtual presence for the ops team on Mars
- RSVP has fully integrated high fidelity simulations of all rover motion commands and utilizes actual flight code for key elements.

RSVP Heritage

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- **RSVP design based on lessons learned**
  - **From design of similar software systems to control:**
    - Blue Rover 1985
    - Robby 1988
    - RTTV Hummvee 1990
    - Gofor 1991
    - Rocky series leading up to Sojourner 1991-1995
    - Mars Pathfinder Sojourner 1997 (RCW)
  - **Each system had both rover command editing and visualization subsystems**
  - **Capabilities and sophistication evolved over time culminating in our current design**
  - **New capabilities coming from technology development in area of robotic simulation, high speed graphics, data driven systems**
- **Rover Control Workstation (RCW) is the only system ever developed to actually control a rover on Mars.**
- **Current development team members have extensive experience in this area, Cooper on all previous listed projects and Hartman on Sojourner.**

Driving Requirements

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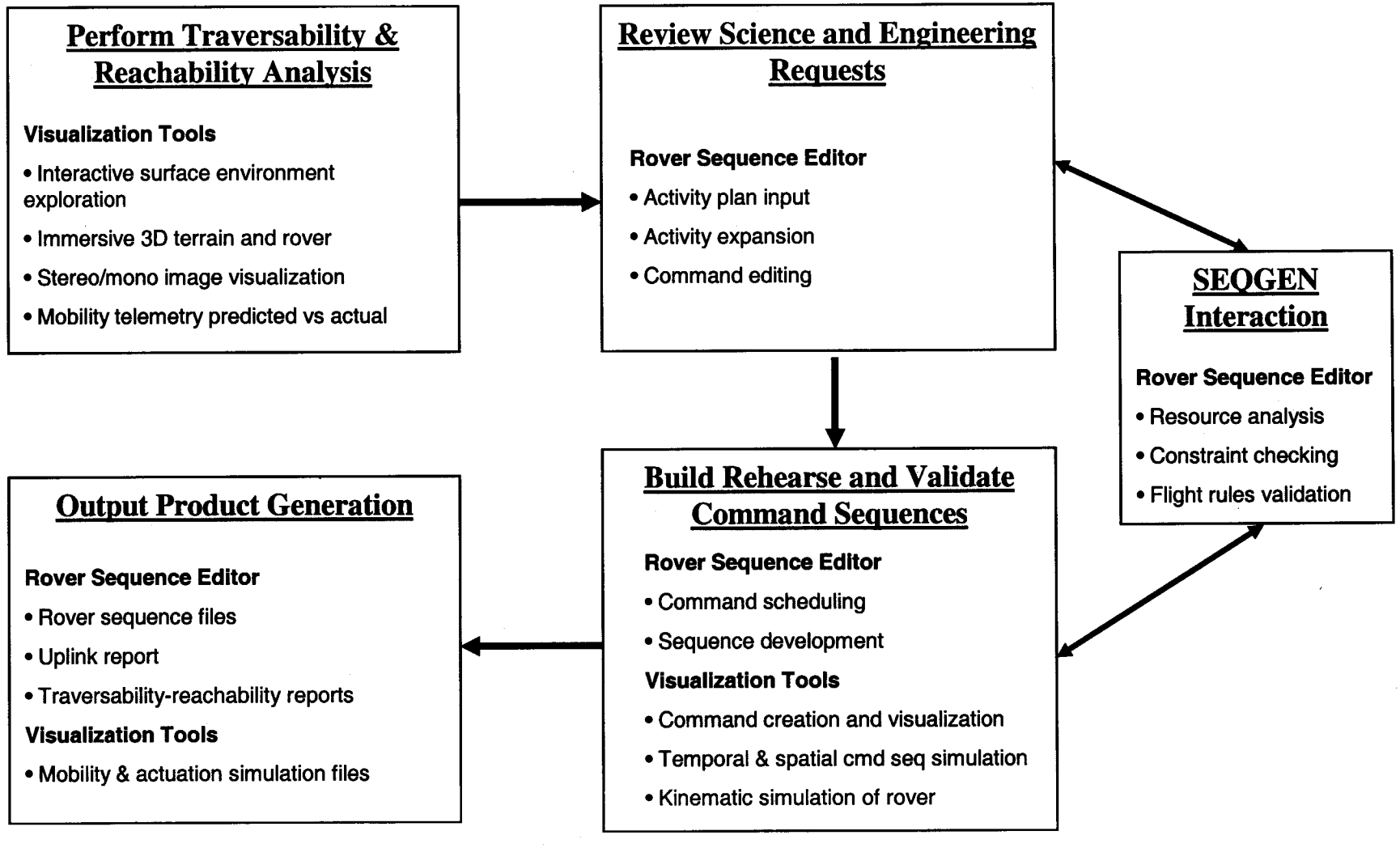
- Full Functional Allocation of Requirements found in SDD

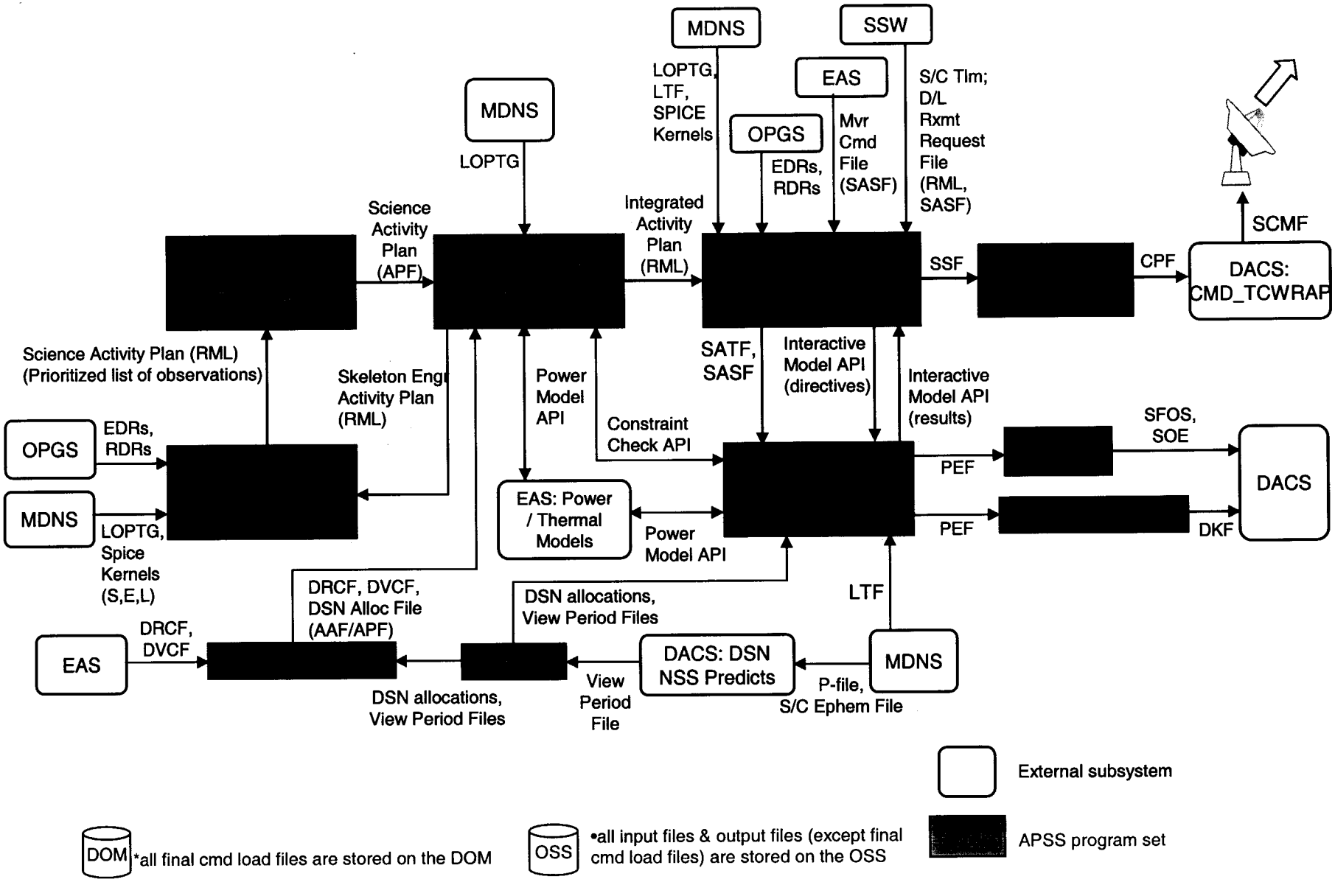
Paraphrasing our key requirements: RSVP Shall:

- Receive activity plans and turn these into complete sets of command sequences for each rover every Sol
- Support traversability and reachability analyses
- Provide an efficient editor for all commands in the command dictionary
- Interact with SEQGEN to perform flight rules, constraints and resource checking and validation on all command sequences
- Produce SASF, SATF, SSF, RML, RKSML, Uplink Reports
- Read OPGS produced files eg. images, terrain models etc. from OSS
- Provide high performance visualizations for images (in stereo) and terrain models of the Martian environment
- Provide simulations of all rover kinematic motions in support of creating all motion based commands in the dictionary

RSVP Capabilities and Functional Flow



How RSVP Fits into the MER Ground Data System



Design Philosophy, Assumptions and Constraints

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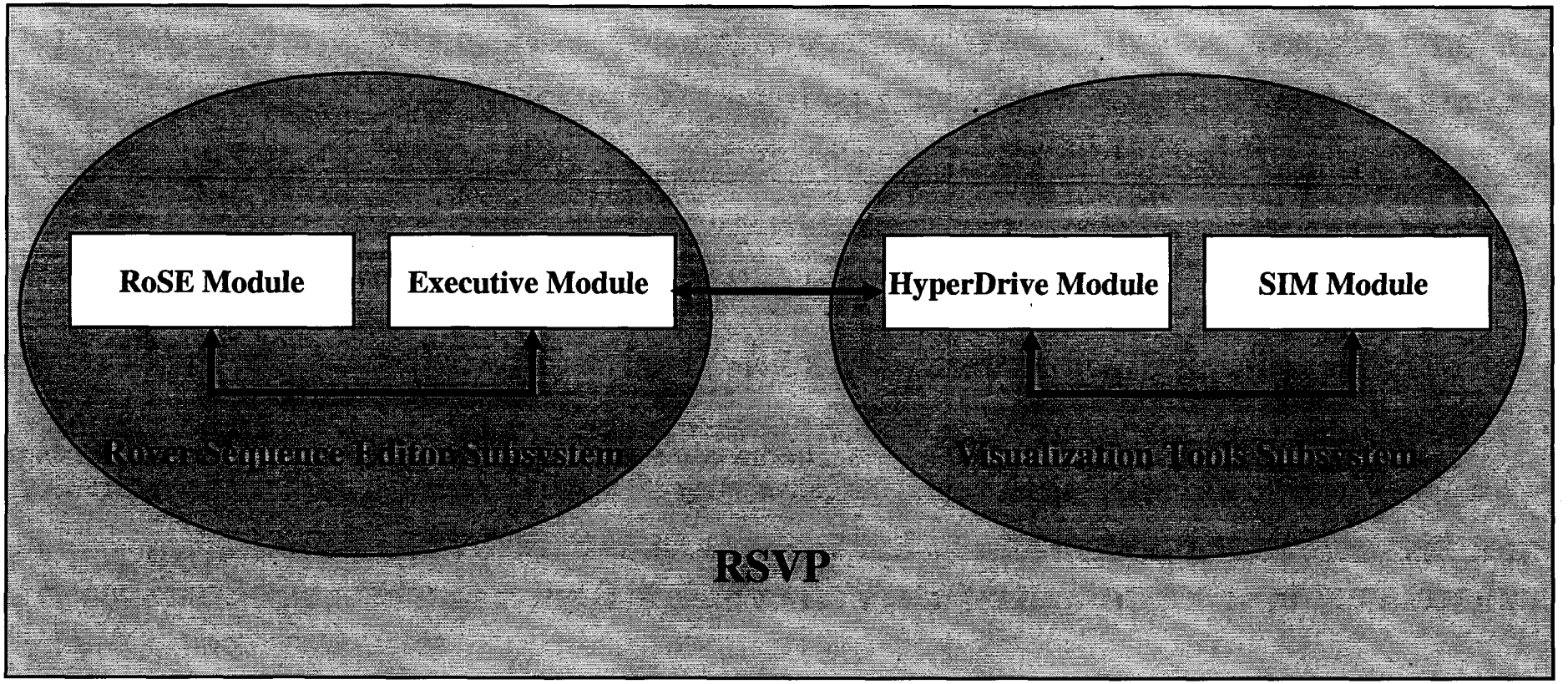
- RSVP has been designed to provide the best possible command sequence editor and the best possible visualizations of the mission data needed to command the twin MER rovers every Sol
- Operations scenarios allow for very short time periods each Sol to make use of RSVP
- This constraint led us to adopt a design philosophy based on program efficiency, performance and operator usability being paramount

- Supported platforms:
- Any Linux PC (x86 CPU)
- Any SGI running Irix OS
- Performance scales with number of CPU's (ideal is 4 or better) and Quality of Graphics subsystems

Design: Program Set Architecture



Analysis: Tradeoffs and Decisions

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- RSVP has four recurring themes found throughout the design
  - Data driven
  - Design Patterns
  - Multiple threads
  - Maximum performance

Analysis: Tradeoffs and Decisions (cont)

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Data driven design

- **Separate code from data whenever possible**
- **Examples found in:**
  - **Rover Sequence Editor (RoSE): command dictionary file defines all specifics of commands**
    - Code becomes immune to changes in these commands
  - **Visualization Tools (HyperDrive): command config file defines subset of commands to be uniquely handles by these tools.**
    - Allows us to autogenerate 10,000+ lines of code pertaining to command specifics from only a small initial file
- **Huge benefit to code portability**
- **As new command dictionaries come out we laugh at the changes**
  - **RoSE can be run with just a new file pointed to**
  - **Visualization tools need simple reautogen and recompile in most cases**

Analysis: Tradeoffs and Decisions (cont)

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Design Patterns methodology used where practical

- Defined in industry standard book from Gamma et.al.
- Enables reuse of well tested techniques and practices
- Makes it easy to communicate design ideas across team
- Makes documentation of design easier
- For example we use "Model-View-Controller", "Factory" and "State" patterns among others

Use Multiple Threads (or processes) when necessary

- Separation of subsystems for development and execution purposes
  - Rover Sequence Editor and Visualization tools subsystems
- We use asynchronous threads running on separate CPUs, if available, for tasks that take time and would otherwise lockout operator interaction
- Examples are SEQGEN interactions and full rover simulations

Analysis: Tradeoffs and Decisions (cont)

Design for Maximum Performance

- In a tool with human interaction with 3D graphics there is nothing more frustrating than low screen update rates and sluggish response to mouse and keyboard inputs
- Ops team will be expected to view and *understand* a tremendous amount of data each Sol
  - What does the science team want
  - What engineering needs to get done
  - Where can we send the rover, arm etc
  - Where are the hazards, where are the goals
- Ops team will be asked to create sets of validated command sequences with up to 1500 arcane rover commands each Sol

This has influenced our choice of hardware platform, OS, programming languages and libraries

Rover Sequence Editor (RoSE)

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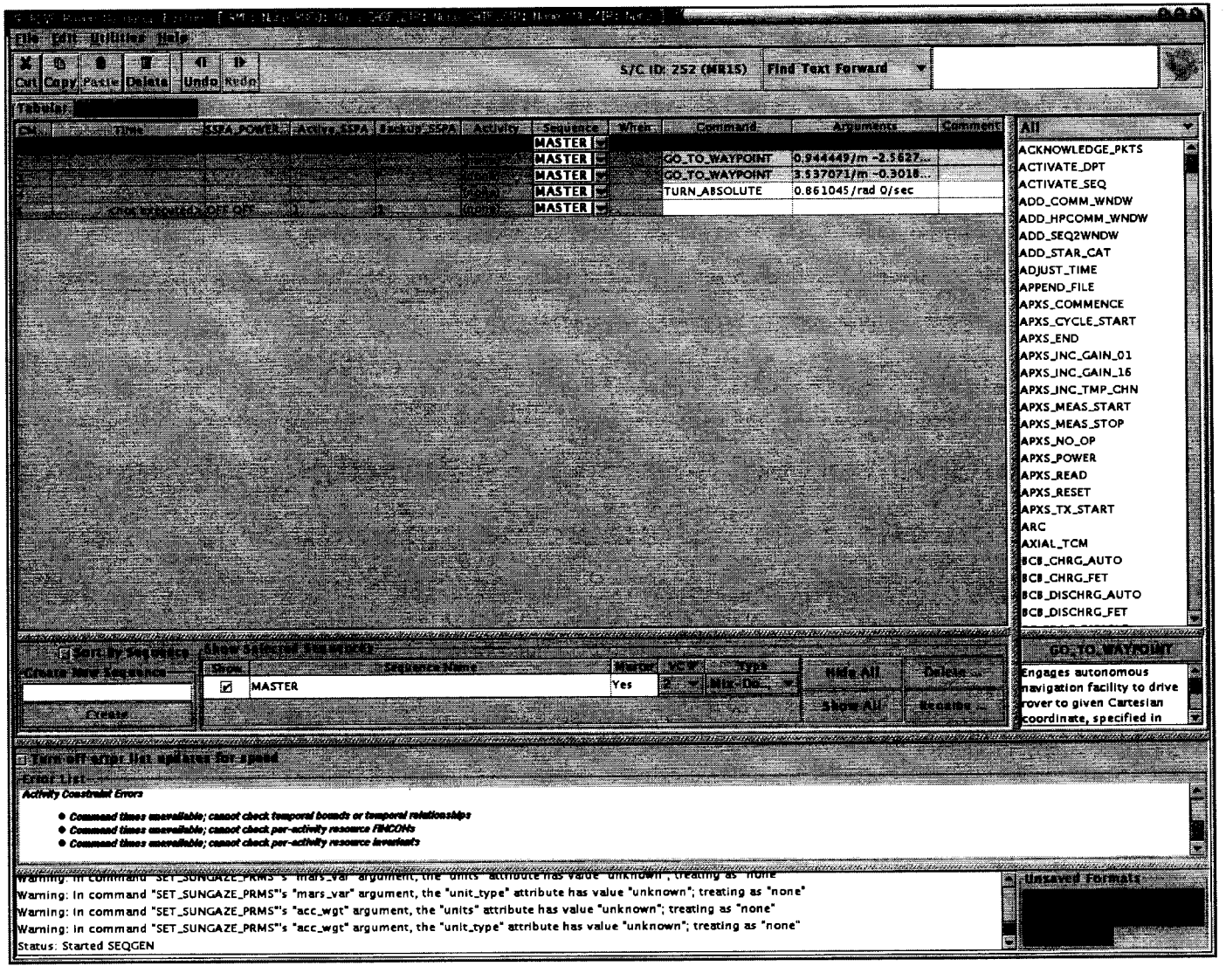
- Comprehensive editor for all rover commands
- Launch/stop all RSVP tools
- Read/write several I/O formats: RML, SASF, SATF, SSF
- Expand activities to commands
- Resource modeling (via SEQGEN), argument validity checking, etc.
- Automatically generate uplink reports
- Aggressively data-driven, mostly by XML files
  - Command and activity dictionary
- Automated self-testing
- Tests run nightly or on demand
- About 15% of code is self-test code
- Design patterns

RSVP-RoSE Screenshot



HyperDrive

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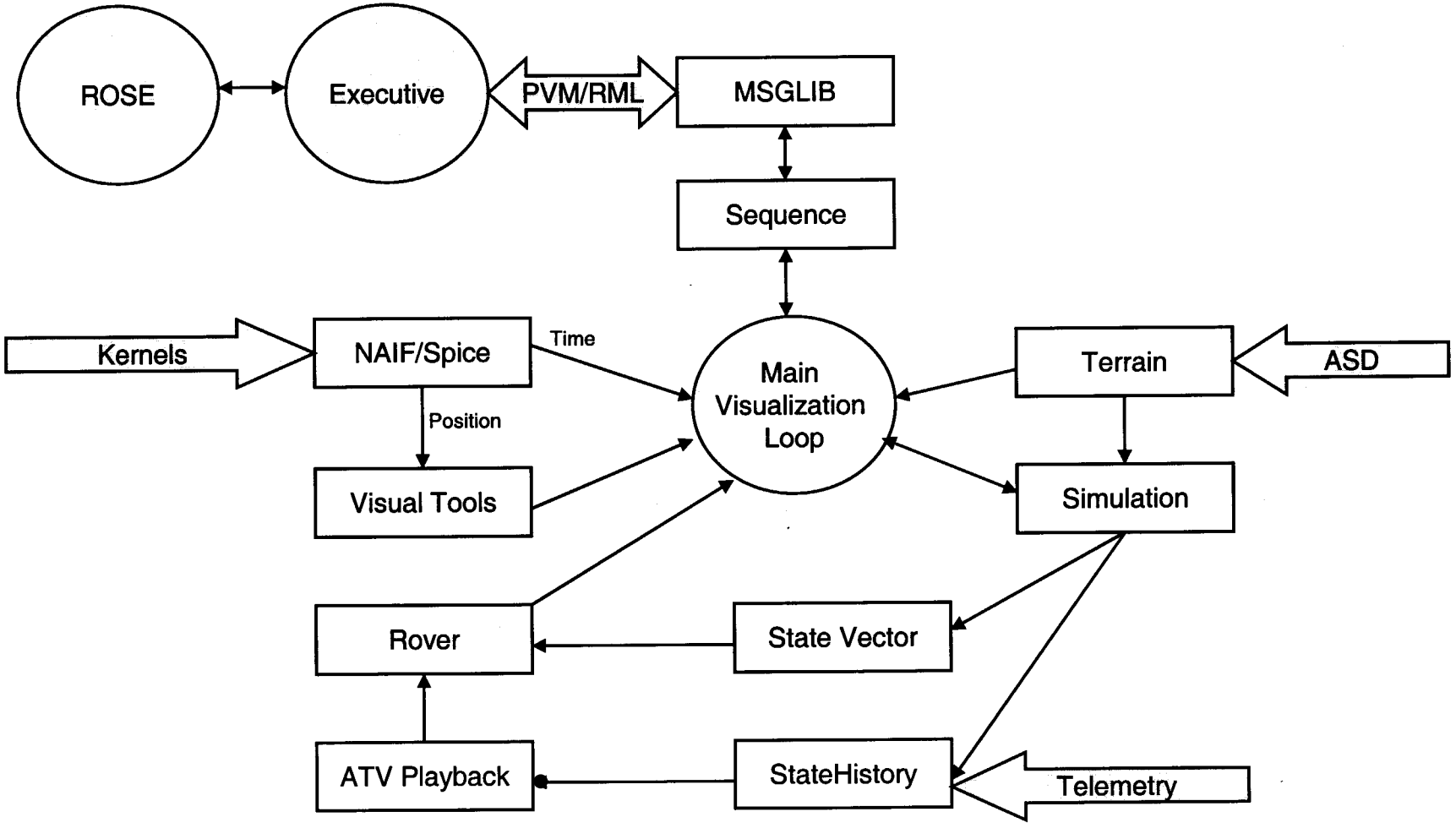
- HyperDrive is the RSVP visualization component
- HyperDrive is based on MPF heritage software for driving Sojourner
- Design considerations
  - Rendering performance
    - Highest priority
  - Cross platform portability
    - Linux and Irix
  - Architectural simplicity
  - Modularity
  - Easy GUI development
- API choices
  - OpenGL Performer
  - GTK+ GUI toolkit
  - libGlade

HyperDrive Architecture



RSVP-HyperDrive Screenshot

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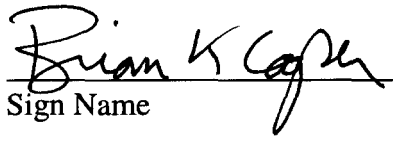

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